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NASA TECH BRIEF

Marshall Space Flight Center

Composite Casting Demonstration

A composite casting demonstration was designed for implementation during the fly-back phase of the Apollo 14 Moon Mission. The demonstration was performed to experimentally assess the potential advantages in the processing of materials in space, and specifically, to determine the effects of the lack of density segregation and heat convection in the weightless environment of space.

In the initial phase of the project, organic and inorganic materials were screened for suitability as simulants for metal matrix and immiscible liquid composites. Laboratory tests were conducted to determine solidification behavior, wetting, chemical compatibility, and flammability characteristics. Materials screened included inorganic salt hydrates, salt eutectics, fluorocarbons, organic phosphates and silicates, and low-melting organics. Fibers, whiskers and particles of metals, carbon, and inorganics were considered for reinforcing materials.

A series of 18 samples, representing four experiment categories, were selected for the demonstration, and 11 of the 18 were actually processed in space. Several of the samples were melted and resolidified without intentional agitation to permit evaluation of particle redistribution. The rest of the samples were manually agitated to achieve a reasonable mixture of particles and/or gas bubbles in the liquid-phase base material. The four categories represent composite structures which cannot presently be made on earth due to density segregation and convection effects caused by gravitational forces. They include (1) particle dispersion in metal matrix or model matrix, (2) gas and particle dispersion, (3) immiscible dispersions, and (4) solidification of metal matrix and free casting.

In the second phase of the demonstration, a post-flight examination and evaluation of the processed samples was conducted, including a comparison of the samples with earth processed control samples. The examination consisted of initial characterization, metallographic study by optical and electron microscopy, chemical analysis, X-ray diffraction analysis, and pore size and volume distribution measurements. Laboratory tests were conducted to confirm selected observations and to make recommendations for performing subsequent composite casting experiments in space.

In comparing the flight and control samples, observation of the macrostructure and microstructure indicate that solidification in both flight and control samples was not unidirectional, a problem that can be solved in the experimental design and procedure. Even without directional solidification, several interesting differences were noted between flight and control samples. Apparent intermittent contact of the melt with the container in the flight samples led to unusual nucleation and growth structures. There was a greater uniformity, on a macro scale, of both pores and structural features in the flight sample, presumably the result of the reduced gravity conditions. Although the spheres and whiskers did not wet the matrix adequately, the flight experiment clearly demonstrated that it is feasible to produce enhanced dispersions of gases and dense phases in a melt that is solidified in reduced gravity. The use of whiskers appears to enhance the retention and uniform distribution of gas bubbles. The analyses of the flight and control samples suggest several modifications or new approaches for future experiments.

(continued overleaf)

Note:

Requests for further information may be directed to:

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Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to:

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